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Author:	J. L. Edwards
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Contractor:	Artificial Intelligence Management and Development Corporation (AIMDC) 206 Keewatin Avenue, Toronto, Ontario M4P 1Z8, CANADA
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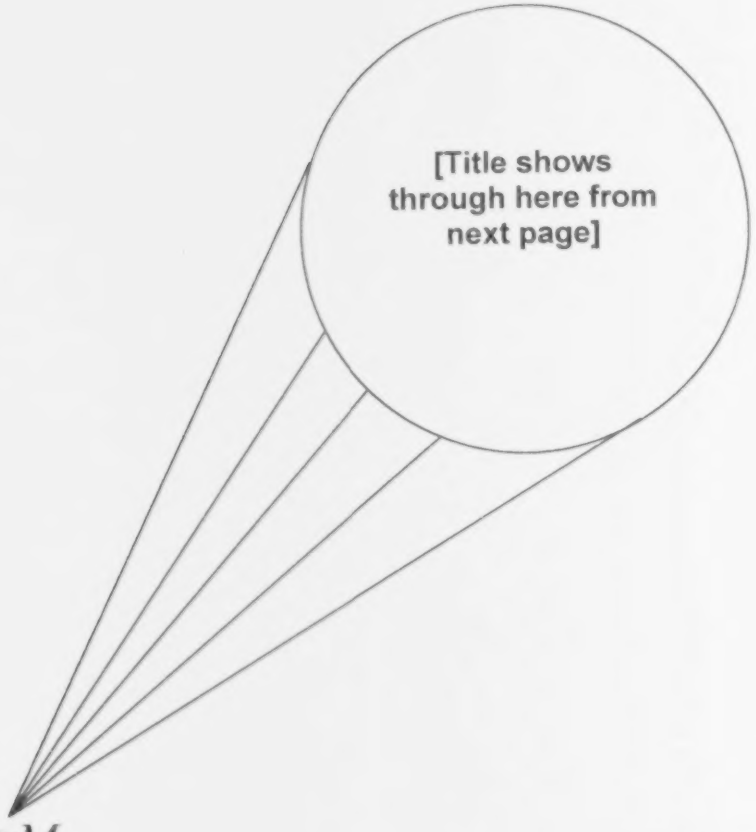

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Author: J. L. Edwards, Artificial Intelligence Management and Development Corporation
Contractor: Artificial Intelligence Management and Development Corporation (AIMDC)
206 Keewatin Ave., Toronto, Ontario, Canada M4P-1Z8
Contract: W7711-02-7823/001/TOR
Contract Scientific Authority:
Mr. Keith Hendy,
Head, Human Factors Research and Engineering Section
Establishment: Defence R&D Canada Toronto (DRDC Toronto)
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Design and Implementation of Extensions to SERA

- Final Report -

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Abstract

Extensions are described for the Systematic Error and Risk Analysis (SERA) tool. SERA presents an investigator with a series of theoretically based questions and analyses the respondent's answers in terms of the source of failure and pre-conditions that led to that failure. Individual investigations using SERA may be saved and returned to at a later time and reports are available for export as text files, which then can be imported into a word processor for formatting. Extensions to SERA included accommodation for the investigation of multiple unsafe acts and porting of the software to a Personal Digital Assistant (PDA) for effective use in field settings. SERA provides a clear and intuitive interface, context-sensitive help and a foundation for intelligent aiding through an ability to track and represent user actions at the interface. Among the recommendations for future work were reliability and usability testing, designing and implementing an interface to accommodate voice input, where text would otherwise have to be keyed in by hand, and suggestions for intelligent aiding including the possible use of case-based reasoning.

Résumé

On décrit ici un certain nombre d'extensions de l'outil ASER (analyse systématique des erreurs et du risque). Cet outil présente à l'enquêteur une série de questions théoriques et analyse ses réponses en termes de la cause de la défaillance et des conditions préalables qui l'ont provoquée. Les résultats d'enquêtes individuelles effectuées au moyen de l'outil ASER peuvent être sauvegardés et consultés ultérieurement, et les rapports peuvent être exportés sous la forme de fichiers texte; ces derniers peuvent ensuite être importés dans un traitement de texte pour être mis en page. Les extensions de l'outil ASER comportent la prise en compte dans l'enquête d'actes dangereux multiples, ainsi que le portage du logiciel sur un PDA (pour Personal Digital Assistant ou assistant numérique personnel) en vue d'une utilisation efficace sur le terrain. L'outil ASER comporte une interface claire et intuitive, une aide contextuelle, et les bases nécessaires pour une assistance intelligente, grâce à sa capacité de suivre et de représenter les actions entreprises par l'utilisateur au niveau de l'interface. Parmi les recommandations présentées en vue de travaux ultérieurs, citons des tests de fiabilité et d'utilisabilité, la conception et la mise en œuvre d'une interface vocale, permettant d'éviter la saisie du texte au clavier, et des suggestions pour une aide intelligente, notamment l'utilisation potentielle de raisonnements basés sur des cas.

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Executive Summary

Extensions to the Systematic Error and Risk Analysis (SERA) tool were performed using IP/PCT theory and Hendy's derived conceptual tool. The two key extensions included an accommodation for the investigation of multiple unsafe acts and a re-design and implementation of the modified version for a Personal Digital Assistant (PDA).

On all platforms, the tool now guides an investigator through a step-by-step process for each of several unsafe acts that characterises an accident in terms of active failures and their pre-conditions. As with the earlier implementation, principal elements of the program include: an easy to use interface; the potential for linking to an external database; standard and intelligent help; and, cross-comparisons to similar results from the HFACS tool.

The SERA tool leads the investigator through a series of yes or no questions modelled on Hendy's flowcharts. Those questions follow decision ladders which lead to conclusions about the active failures that caused the accident and the pre-conditions that led to those failures. At each stage in the questioning the user is given the option of adding textual information in the form of comments relevant to that stage of the analysis. Those notes provide details on the accident or incident being investigated and will be useful to other investigators reviewing the results.

At the conclusion of the question-answering phase, the SERA tool presents the user with an assessment of the type(s) of failure that led to the accident and a list of possible pre-conditions that could have been present for the failure to occur, with the most likely ones highlighted.

Validation of the SERA approach provides, as part of the output, cross-comparisons to equivalent terminology used in the Canadian Forces modified AGA 135 Human Factors Accident Classification System (HFACS).

Information on all failures and their pre-conditions is summarised and organised into a report that is available to the investigator. AGA 135 HFACS equivalents are included in that output.

Help is provided to users at each stage in the process. For each question presented, context-sensitive help is readily accessible, including definitions of terms and descriptions of factors to consider in answering the particular question under review.

A graphical overview of the line of questioning showing where the user is in the process is available for each of the unsafe acts identified. Such overviews are useful not only in identifying exactly where the user is in the questioning but also in providing a graphical representation of the underlying theory as it is realised in the SERA model. The overview can be used to navigate quickly to different parts of a questionnaire within an given unsafe act being investigated.

SERA's capability for tracking an investigator's interface actions was extended to all actions for all of the unsafe acts addressed for a given accident. The tracking is a basis for helping to identify areas of potential confusion in content and procedure, e.g., if the user repeatedly returns to modify the answer to an earlier question. When appropriate, SERA initiates a review of such questions with the user at key points during a session to help clarify and correct the sources of the user's confusion. Confusion may arise either on the part of an investigator or those being questioned about the accident.

Beyond laying a foundation for intelligent aiding, the tracking capability provides information potentially helpful in refining the interface and the SERA methodology, e. g.,

information that could lead to the re-phrasing of questions for clarity would constitute feedback on software usability.

Among other things, the user interface tracking includes information about the timing of the user's input, which allows the system to offer help to the user when it detects a long delay in answering a question.

The above functionality, available on Macintosh and PC platforms, was ported to a re-designed SERA running on a Personal Digital Assistants (PDA) under the Windows CE operating system. The particular hardware platform on which the re-designed SERA was implemented was the Compaq iPaq PC H3950. Surprisingly, little alteration of the interface was required in the re-design. One decrement to implementing SERA on this much smaller platform was a slight reduction in performance but not sufficient to interfere with the effective use of the tool. A second, standard decrement for all PDAs is font size, but the high resolution of the screen makes reading text an acceptable task.

Among the recommendations for future work were reliability and usability testing, designing and imp'ementing an interface to accommodate voice input, where text would otherwise have to be keyed in by hand, and suggestions for intelligent aiding including the possible use of case-based reasoning.

Also recommended for consideration is incorporating the search-and-retrieval approaches of agent technology as a way of exploring the world wide web for information relevant to particular failures and pre-conditions. Using agents could provide a means of providing up-to-date information on problem-domain topics that would not be possible using a static help system.

Sommaire

Des extensions ont été apportées à l'outil ASER (analyse systématique des erreurs et du risque), en appliquant la théorie IP/PCT ainsi que l'outil conceptuel dérivé de Hendy. Les deux principales extensions permettent de prendre en compte l'examen d'actes dangereux multiples, et on a mis en œuvre une version restructurée du logiciel pour PDA (pour Personal Digital Assistant ou assistant numérique personnel).

Sur toutes les plates-formes, l'outil guide maintenant l'enquêteur à travers un processus étape par étape, pour chacune des actions dangereuses qui caractérisent un accident en termes de défaillances actives et de leurs conditions préalables. Comme dans la version précédente, les principaux éléments du programme comprennent : une interface conviviale; la possibilité de relier le logiciel à une base de données externe; une aide standardisée et intelligente; et des comparaisons croisées avec des résultats semblables obtenus au moyen de l'outil HFACS.

L'outil ASER guide l'enquêteur à travers une série de questions dichotomiques modélisées sur les organigrammes de Hendy. Ces questions suivent des échelles décisionnelles qui conduisent à des conclusions sur les défaillances actives qui ont causé l'accident ainsi que sur leurs conditions préalables. À chaque étape du questionnaire, l'utilisateur se voit offrir la possibilité d'ajouter des informations textuelles sous la forme de commentaires concernant cette étape particulière de l'analyse. Ces notes fournissent des détails sur l'accident ou sur l'incident qui fait l'objet de l'enquête, et elles s'avéreront utiles aux autres enquêteurs qui examineront plus tard les résultats. À la conclusion de l'étape de questions-réponses, l'outil ASER présente à l'utilisateur une évaluation du ou des types de défaillances qui ont provoqué l'accident ainsi qu'une liste des conditions préalables pouvant avoir causé ces défaillances, les plus probables étant mises en évidence.

La validation de l'approche mise en œuvre par l'outil ASER fournit, parmi les résultats, des comparaisons croisées avec la terminologie équivalente utilisée dans le système modifié de classification des accidents causés par un facteur humain (HFACS pour Human Factors Accident Classification System) des Forces canadiennes (AGA 135). Les renseignements sur toutes les défaillances ainsi que leurs conditions préalables sont résumés et organisés dans un rapport qui est mis à la disposition de l'enquêteur. Les équivalents dans le système HFACS (AGA 135) sont inclus dans les résultats.

À chaque étape du processus, l'utilisateur peut obtenir de l'aide. Pour chaque question présentée, une aide contextuelle est accessible; elle comprend une définition des termes utilisés ainsi qu'une description des facteurs qui doivent être pris en compte dans la réponse à la question particulière concernée. Pour chaque action dangereuse identifiée, l'utilisateur peut obtenir un aperçu graphique de la ligne de questionnement indiquant où il se trouve dans le processus. Cet aperçu graphique s'avère utile pour déterminer à quel endroit exactement l'utilisateur se trouve dans le processus de questionnement, et pour obtenir une représentation graphique des principes sous-jacents mis en œuvre dans le modèle ASER. Il peut être utilisé pour naviguer rapidement entre les différentes parties d'un questionnaire portant sur une action dangereuse déterminée faisant l'objet de l'enquête.

Les capacités de l'outil ASER qui lui permettent d'effectuer un suivi des actions entreprises par l'enquêteur au niveau de l'interface ont été étendues à toutes les actions pour tous les actes dangereux pris en compte dans un accident déterminé. Ce suivi constitue une base qui aide à déterminer les endroits dans le contenu ou la procédure pouvant porter à confusion,

par exemple lorsque l'utilisateur retourne plusieurs fois en arrière pour modifier sa réponse à une question antérieure. Lorsqu'il le juge approprié, l'outil ASER amorce avec l'utilisateur un examen de ses questions à des points essentiels pendant la session, pour aider à clarifier et à corriger les sources de confusion. Cette confusion peut provenir de l'enquêteur ou des personnes qui sont interrogées concernant l'accident.

En plus de constituer la base d'une assistance intelligente, la fonction de suivi fournit des renseignements qui peuvent s'avérer utiles pour affiner l'interface de l'outil ASER et la méthode qu'il met en œuvre; ainsi, des renseignements pouvant amener la reformulation des questions, pour plus de clarté, constituent une réaction sur la convivialité ou l'utilisabilité du logiciel. Notamment, la fonction de suivi de l'interface utilisateur comporte des renseignements sur le moment où les données sont entrées par celui-ci, ce qui permet au système de lui offrir une aide lorsqu'il détecte qu'il prend trop de temps pour répondre à une question.

Les fonctionnalités ci-dessus, disponibles sur une plate-forme Macintosh ou PC, ont été portées sur un logiciel ASER restructuré tournant sur un PDA (assistant numérique personnel) sous le système d'exploitation Windows CE. L'outil ASER restructuré a été mis en œuvre sur la plate-forme matérielle Compaq iPaq PC H3950. Fait surprenant, cette restructuration a nécessité d'apporter peu de modifications à l'interface. Un inconvénient de la mise en œuvre de l'outil ASER sur cette plate-forme réduite : une légère dégradation des performances, qui n'est toutefois pas suffisante pour nuire à une utilisation efficace de l'outil. Un deuxième inconvénient, commun à tous les PDA : la réduction de la taille des caractères, mais, grâce à la résolution élevée de l'écran, la lecture du texte demeure quand même une tâche acceptable.

Parmi les recommandations présentées en vue de travaux ultérieurs, citons des tests de fiabilité et d'utilisabilité, la conception et la mise en œuvre d'une interface vocale, permettant d'éviter la saisie du texte au clavier, et des suggestions pour une aide intelligente, notamment l'utilisation potentielle de raisonnements basés sur des cas. Il est également recommandé d'envisager d'intégrer à l'outil les méthodes de recherche et d'extraction de la technologie des agents, afin de permettre d'explorer le Web et d'y trouver des renseignements concernant des défaillances particulières et leurs conditions préalables. L'utilisation d'agents permettrait d'obtenir sur les problèmes des renseignements à jour, impossibles à obtenir autrement au moyen d'un système d'aide statique.

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Background

Recent work for DRDC Toronto (W7711-01-7756) produced a software tool for human factors accident investigation and classification. The Systematic Error and Risk Analysis (SERA) tool (Hendy, 2002) presents the investigator with a series of theoretically based questions and analyses the respondent's answers in terms of the source of failure and pre-conditions that led to that failure.

Beyond its basic functionality, which includes standard, context-sensitive help, work on SERA also provided a foundation for intelligent aiding by incorporating an ability to monitor user actions at the interface and identify their context, including the interface objects involved, where the user is located in the investigative process, and timing information.

The rationale for constructing SERA is the need to identify and eliminate factors leading to accidents, so as to prevent future recurrences. As a result of advances in equipment reliability, accidents today are more likely to be the result of human rather than mechanical error. To facilitate the investigation of those human errors, it is useful to have a systematic process for analysing the causes of failures and the predisposing conditions that lead to those failures. While other accident investigation tools are based on descriptive models, SERA is grounded in a theoretical approach that combines Information Processing and Perceptual Control theories (Hendy, East, and Farrell, 2000; Hendy, Liao, and Milgram, 1997; Powers, 1973). SERA provides:

- a tool for investigating the human factors causes of accidents and incidents;
- a means of classifying accidents and incidents; and
- the basis for a risk management tool.

To prevent future accidents, causes need to be identified and steps taken to eliminate the conditions that led to the error. Current accident investigation tools, such as the Human Factors Accident Classification System (HFACS) used by the Canadian Forces Directorate of Flight Safety, have been developed by analysing factors that contributed to a series of specific accidents. Because they lack a sound theoretical foundation, it is difficult to say whether they model cause-and-effect relationships in a consistent and reliable manner. In contrast, SERA provides a theoretical basis for identifying cause and effect relations in accident investigations and is subject to checks on consistency and completeness as well as reliability and validity.

In addition to helping determine the type of failure that occurred, SERA identifies the most likely pre-conditions that led to the failure. Those conditions are ones that would have to be changed in order to prevent a recurrence of the incident. A significant advantage of SERA is that it provides a more comprehensive taxonomy of failures and pre-conditions than existing accident investigation and classification tools like HFACS. HFACS was developed by analysing a database of specific accidents, so there is the risk that its taxonomy is incomplete, inconsistent or redundant due to limitations in the data. In contrast, the theoretical underpinnings of the SERA model help ensure the development of a complete and consistent taxonomy.

In order to facilitate the use of the SERA model, the SERA tool was constructed to provide accident investigators with an efficient way to perform SERA analyses and to facilitate the collection of data to help refine the SERA model itself.

What is needed now is a way for investigators to address multiple unsafe acts that have contributed to a single accident. In addition, since accident investigation often is conducted "in the field," there is a need to port SERA to a handheld PDA as a way of making the tool more useful and adaptable to accident investigators. This project seeks to address those issues.

The purpose of this contract will be to modify the existing SERA software tool to accommodate multiple unsafe acts for a given accident. Similar to the current version, the software tool will present the investigator with a series of questions for each of the unsafe acts identified and separately analyse and produce a report of the respondent's answers in terms of the source of failure and pre-conditions that led to that failure. Since PDAs require substantially reduced interfaces vis-à-vis those implemented for standard computer screens, a redesign of the current interface will be performed and a version of SERA (PDA) will be implemented.

Finally, the foundation for intelligent aiding laid in earlier work on SERA will be extended by tying the interface actions of an investigator to representations of associated goals and subgoals, as the investigator makes use of the tool.

Study Objectives

The objectives of this contract were:

- To design and implement extensions to a software tool that will lead accident investigators through the steps of a SERA analysis. Following the original intent of the software, it will maintain and extend as applicable the following features:
    - A clear, intuitive interface that presents the user with a series of questions based on the decision ladders outlined in the Hendy's SERA technical report. This guideline applies to extensions for the standard PC platform and to the redesign of the SERA interface for the PDA platform;
    - Summary conclusions about the nature of the failure(s) and probable pre-conditions that could have led to the various types of failure identified;
    - A separate, easily accessible overview for each of the unsafe acts investigated;
    - A report detailing findings for the unsafe acts identified;
    - A revision support function allowing users to modify responses to previous questions;
    - A design and draft implementation of SERA for a Windows CE PDA;
    - Context-sensitive help at each stage of the analysis, with definitions of terms and other relevant background information presented.
- To provide for both system and user cross-comparisons to HFACS terminology;
- To provide support for intelligent aiding in the following forms:
    - Tracking user interface actions and inference of associated goals and subgoals;
    - Offering of help when there are excessively long delays without user input;
    - Offering of help in the face of apparent confusion on the part of the user (e.g. when SERA's conclusions are at odds with the user's understanding of the situation);
    - Possibly incorporating an information-retrieval agent for obtaining up-to-date information on failures and pre-conditions from the world wide web.

Overview of the Design and Implementation of Extensions to SERA

Using IP/PCT theory and Hendy's derived SERA conceptual tool, the existing software system was extended to accommodate the investigation of multiple unsafe acts. Similar to its current support for single unsafe act investigation, the tool now guides an investigator through a step-by-step process for each of several unsafe acts that characterises an accident in terms of active failures and their pre-conditions. As with the earlier implementation, principal elements of the program include: an easy to use interface; the potential for linking to an external database; standard and intelligent help; and, cross-comparisons to similar results from the HFACS tool.

The SERA software tool leads the investigator through a series of yes or no questions modelled on Hendy's flowcharts. These questions follow decision ladders which lead to conclusions about the active failures that caused the accident and the pre-conditions that led to those failures. At each stage in the questioning the user is given the option of adding textual information in the form of comments relevant to that stage of the analysis. Those notes provide details on the accident or incident being investigated and will be useful to other investigators reviewing the results.

At the conclusion of the question-answering phase, the SERA tool presents the user with an assessment of the type(s) of failure that led to the accident and a list of possible pre-conditions that could have been present for the failure to occur, with the most likely ones highlighted.

For validation of the SERA approach, part of the output from the initial work included cross-comparisons to equivalent terminology used in the Canadian Forces modified AGA 135 Human Factors Accident Classification System (HFACS). Such cross-comparisons were extended for each unsafe act identified.

Information on all failures and their pre-conditions is summarised and organised into a report that is available to the investigator. Questions and answers are presented in logically integrated format in that report.

As in the initial work on SERA, help is available to the user at each stage in the process. For each question presented, context-sensitive help is readily accessible including definitions of terms and descriptions of factors to consider in answering the particular question under review. A graphical overview of the line of questioning showing where the user is in the process was included in the first implementation of SERA.

Now, a separate overview is available for each of the unsafe acts identified. Such overviews are useful not only in identifying exactly where the user is in the questioning but also in providing a graphical representation of the underlying theory as it is realised in the SERA model.

SERA's capability for tracking an investigator's interface actions was extended to all actions for all of the unsafe acts addressed for a given accident. That tracking is a basis for helping to identify areas of potential confusion in content and procedure, e.g., if the user repeatedly returns to modify the answer to an earlier question. As appropriate, the system will review such questions with the user at key points during a session to help clarify and correct the

sources of his or her confusion. Confusion may arise either on the part of an investigator or those being questioned about the accident.

Beyond laying a foundation for intelligent aiding, the tracking capability provides information potentially helpful in refining the interface and potentially the SERA methodology, e. g., information that could lead to the re-phrasing of questions for clarity would constitute feedback on software usability.

Among other things, the user interface tracking includes information about the timing of the user's input, which allows the system to offer help to the user when it detects a long delay in answering a question.

All of the above functionality was ported to a re-designed SERA for Windows CE supported Personal Digital Assistants (PDAs). The particular hardware platform on which the re-designed SERA was implemented is the Compaq iPaq PC H3950. Surprisingly little alteration of the interface was required in the re-design. The only decrement to implementing SERA on this much smaller platform was a slight reduction in performance. Although this is annoying, it is not sufficient to interfere with the effective use of the tool. As Java (see below) is optimised for this platform, performance will improve.

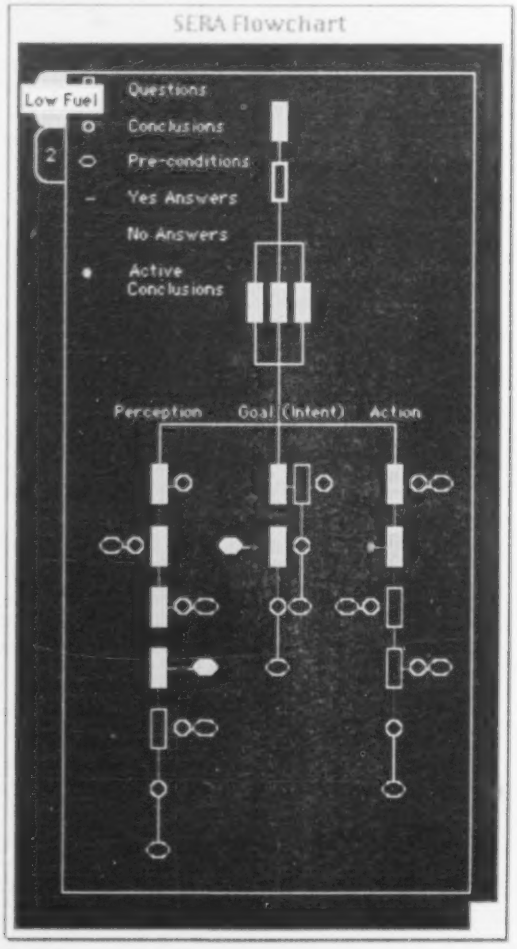
Some further consideration was given to incorporating agent technology to explore the world wide web for information relevant to particular failures and pre-conditions and search and retrieval approaches were identified. Using agents could provide a means for users to obtain up-to-date information on topics that would not be possible using a static help system.

Java continues to be the chosen language of implementation, permitting SERA to run both as a stand-alone application and as an applet accessed via the world wide web and executed in a web browser. This choice now looks even more favourable as many PDAs are moving to provide Java as a language for implementation. Java also allows for portability to other hardware platforms and integration with software agents. The Windows compatibility will enable the software to run on the majority of laptop computers, thus giving greater scope for use in the field. Thus, the extensions to SERA on the PC and its redesign and implementation for the PDA platform will continue to use Java.

Design and Implementation for Accommodating Multiple Unsafe Acts

As specified in the terms of this contract SERA now supports a clear intuitive interface that presents users with a series of questions based on the decision ladders outlined in the Hendy's technical report on SERA. Summary conclusions about the nature of the failure(s) and probable pre-conditions that could have led to the various types of failure identified.

New to the current implementation is a separate and easily accessible overview for each of the unsafe acts investigated. The instantiation of this overview takes the form of a modified flowchart that allows users to move easily among the unsafe acts identified. This is accomplished through the use of tabs displayed down the left-hand side of the flowchart, as seen in the figure below.



By clicking on a tab, a user can move quickly to the investigation of a different unsafe act and then, using the nodes in its associated flowchart, navigate to various sections of the questionnaire. Of course, SERA supports an entirely separate analysis for each unsafe act.

By moving the cursor over the top of a tab, the title that has been given to the unsafe act appears; e. g., in the case illustrated in the above figure, "Low Fuel" is the title given to this unsafe act.

The report facility in SERA now integrates all unsafe acts investigated for a given incident. These are organised sequentially according to their specification by the user. The report can be exported as a text file and then moved into a word processor for formatting.

The revision support function that allows users to modify responses to previous questions has been extended for multiple unsafe acts. If a conclusion that is reached through SERA is inconsistent with the user's understanding of the situation, SERA allows the user to quickly review his or her decisions and make appropriate changes.

Re-Design of SERA for Windows CE Personal Digital Assistant (PDA) Platforms

Acquiring the PDA Hardware Platform

A key element of this contract was to make SERA a tool that is easily used in the field where most investigations take place. To that end, efforts were directed at a re-design of the software for a Personal Digital Assistant (PDA).

As DRDC has standardised on Windows operating systems for their hardware platforms, the range of choices were limited. An investigation revealed that only two hardware platforms supported the Windows CE operating system: the Compaq iPaq and Toshiba 740 PDAs.

Further investigation revealed that both have a 400 MHz Intel XScale processor and 64 MB of RAM. Advantages of the iPaq include a brighter and clearer screen than the Toshiba, slightly less in cost, and apparently the most established of the PocketPC hardware platforms, with the largest selection of compatible accessories. Advantages of the Toshiba 740 include built-in wireless networking (optional on the iPaq) and some limited voice recording.

Given the iPaq's advantages, the decision was made that the re-designed SERA software would be implemented on that platform. After acquiring the iPaqs, it was discovered that the most recently released version supported voice input thus making the iPaq clearly the most desirable of the two platforms.

One final comment about the iPaq is that the optional wireless transfer might be added to the purchased items when conducting usability trials for SERA. This would allow the resulting data to be transferred from the field to a central location for analysis and permit an investigator to explore other elements of the incident or move to another investigation entirely.

As indicated earlier, Java was the chosen language of implementation for the Macintosh and PC platforms and was used to implement SERA on the iPaq PDA. Other PDAs are moving to provide Java as a language for implementation. A German firm is currently working on a version of Java for use with PDAs running under the Palm operating system, which currently is the most popular operating system for PDAs. If that is successful, it should make porting SERA to the Palm a much easier task than it is now.

Re-Design of the SERA Interface for a PDA

The first question raised in considering the re-design of SERA for the PDA was whether interface guidelines existed for PDAs. Microsoft has provided guidelines for PDAs in their Pocket PC development kit in a document called, "Designing a User Interface for Pocket PC 2002." Those were downloaded and studied in preparation for re-tooling SERA to operate on the iPaq.

A draft design was developed that surprisingly adhered closely to the design used on Macintosh and PC platforms. Again, the language of implementation was Java and that meant minimal changes in the code when porting the application to the Compaq iPaq platform.

The principal changes to the interface were as follows:

- Due to the relatively smaller screen real estate, it was not possible to have both the main investigation window and the flowchart displayed at the same time. A new button was added to the main window to allow the flowchart to be displayed;

- Due to the lack of a cursor, items previously activated by moving the cursor over the top of the item could not be activated in that way on the PDA. Clicking was used instead;

- That also was true for the flowchart. New interface actions for the flowchart involve clicking on a node in the flowchart to display the name of the node and, subsequently, clicking a new "Go" button to navigate to that node. When the "Go" button is clicked, the flowchart disappears and the user is taken to that portion of the main window associated with the node;

- "Additional Remarks" sections, associated with many of the screens in the main window, are now activated by selecting a button entitled, "Remarks," which was added at the bottom of those screens. A separate window then appears for entering textual comments;

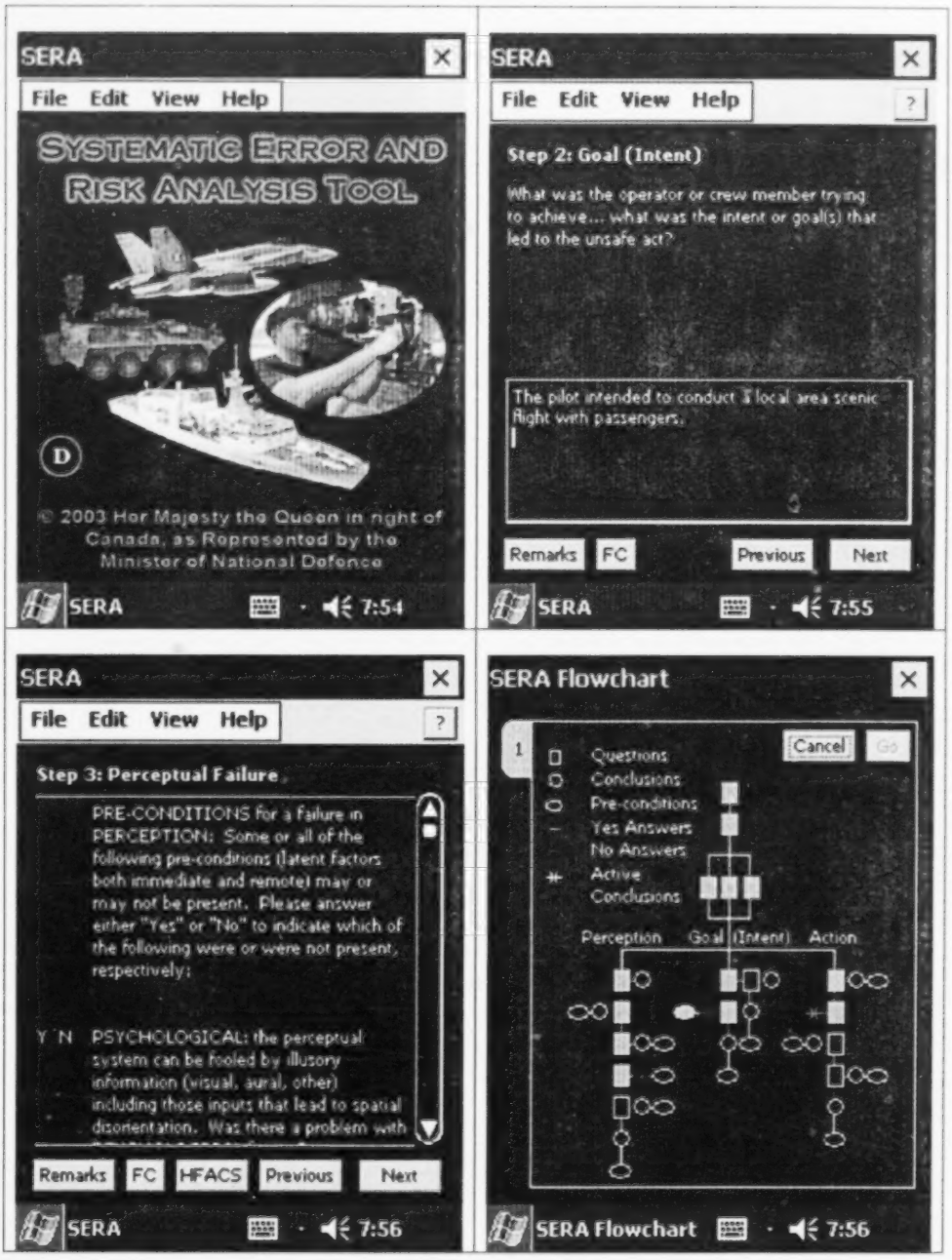
- It was determined that all of the menus are not appropriate when a user navigates to the "Additional Remarks," screens and, so, an appropriate subset of the main window menus are now displayed when the user moves to those screens.

- Due to the slower performance of the PDA Java, relative to Java on the Macintosh and PC platforms, some optimisation was necessary to accommodate the processor and, where more than a few seconds of delay could not be eliminated, a "wait" message is now displayed.

Despite the relatively small number of changes, considerable time was needed to make sure that all of the functionality, including the new additions to support the investigation of multiple unsafe acts, was working properly.

Testing the software identified a number or problems. Solutions for those were found and further testing indicated that the PDA version was working well. The small screen size proved to be only a minor problem in re-design and, its clarity and resolution means that it is easy to use. The smaller font size is a slight problem but for the most part, the characters are easily readable. Those can be seen on the next page in set of screen shots of the SERA interface that includes: the splash screen; a goal/intent question; a decision screen concerning pre-conditions for a perceptual failure and the flowchart overview.

A key bottleneck in the use of any software is data entry. The availability of a keyboard reduces this problem somewhat and a fast typist can be effective at entering data in a reasonable time. For PDAs, useful because they can be taken into the field, data entry poses a greater problem. This topic is elaborated in the section on future work later in this report.


SERA
File Edit View Help
SYSTEMATIC ERROR AND RISK ANALYSIS TOOL
D
© 2003 Her Majesty the Queen in right of Canada, as Represented by the Minister of National Defence
SERA 7:54
SERA
File Edit View Help
Step 2: Goal (Intent)
What was the operator or crew member trying to achieve... what was the intent or goal(s) that led to the unsafe act?
The pilot intended to conduct a local area scenic flight with passengers.
Remarks FC Previous Next
SERA 7:55
SERA
File Edit View Help
Step 3: Perceptual Failure
PRE-CONDITIONS for a failure in PERCEPTION: Some or all of the following pre-conditions (latent factors both immediate and remote) may or may not be present. Please answer either "Yes" or "No" to indicate which of the following were or were not present, respectively:
Y N PSYCHOLOGICAL: the perceptual system can be fooled by illusory information (visual, aural, other) including those inputs that lead to spatial disorientation. Was there a problem with
Remarks FC HFACS Previous Next
SERA 7:56
SERA Flowchart
1
Questions
Conclusions
Pre-conditions
Yes Answers
No Answers
Active Conclusions
Cancel Go
Perception Goal (Intent) Action
SERA Flowchart 7:56

Extended Support for Intelligent Aiding within SERA

The main focus of this contract was to provide users of SERA with a way of identifying and investigating multiple unsafe acts and to port the application to a PDA platform for more effective use in field investigations.

Some supplemental work focused on adding further infrastructure support for intelligent aiding. Taking advantage of earlier work incorporating infrastructure support and intelligent aiding into other software products (e.g., the *LOCATE* workspace layout design tool), code was developed to support the tracking of user interface actions and the inference of associated goals and subgoals in SERA.

Although some context-sensitive help is available in SERA, only the underlying infrastructure has been included in SERA for supporting intelligent aiding. In the current contract, tracking of user interface actions was extended to included the new functionality that supports the investigation of multiple unsafe acts. The same tracking component was incorporated into the new PDA version.

Some of the current context-sensitive help involves help available on each page of the application; displaying a message when there has been an excessively long delay without user input; and, offering help in the face of apparent confusion on the part of the user (e.g. when SERA's conclusions are at odds with the user's understanding of the situation).

The user interface tracking and goal inference serves as a foundation for incorporating intelligent aiding in future designs and implementations of SERA. In addition, intelligent support could be provided through agent technology that retrieves and filters information on failures and pre-conditions from the world wide web.

Future Work

SERA is now a mature tool that can be used with confidence in practical investigations of accidents. Several improvements would add to the usefulness of the tool and inspire greater confidence in users.

The first of these relates to issues of reliability and usability of the tool. DRDC Toronto, with the support of AIMDC, is currently exploring these issues in the context of an assessment and testing of SERA within a well-defined problem domain. A proposal has now been submitted that would see SERA adapted to the domain of railroad accident investigation, analysed with a view to improving its interface appeal and effectiveness, and tested for its ability to produce reliable results among accident investigators. The proposal is part of a joint Canada-US SBIR submission. Pending a successful bid, improvements to SERA would be done by AIMDC.

As mentioned earlier, a key bottleneck in the use of any software is data entry and SERA is no exception. Although it is easy to navigate within the software and make selections using the new implementation of SERA on a PDA platform, field use will require substantial textual input as users work their way through an investigation. At the moment, the only possibilities for doing this involve the use of keyboard or written script, both of which are supported by the iPaq PDA on which SERA has been implemented. An external keyboard is also an option and, although it might make data input easier, it could prove cumbersome in a field context.

An alternative method that could substantially reduce the awkwardness of text entry would be voice input. At the moment, PDAs that support audio input do so only for small audio files. Although the technology for substantial amounts of audio input no doubt one day will be available on all PDAs, it does not exist today. Further, even if such audio support were available, the user likely would need to have those audio files translated into text that could be manipulated and enclosed in a written report. Support for speech recognition within PDAs is likely even more remote for PDAs.

Luckily work on incorporating audio files that can subsequently be converted into text files and integrated into SERA is possible. Technology currently exists that can provide up to 40 hours of audio on a small, hand-held recorder, more than ample for a given investigation. Once audio files are collected, they can be transferred to a computer and analysed by speech recognition software. From there, a customised interface could take the output of the speech recognition analysis and input the results directly into the appropriate locations in a SERA file. A proposal to design and implement such an interface is now in progress.

In addition to producing a report, the SERA tool is constructed to support the potential for output of all of the data, its results and all comments by the investigator to a database. By maintaining a database of all results, investigators could perform large-scale comparisons with previous results from cases investigated using SERA and other tools such as HFACS.

Options for extending the scope of SERA's coverage lies in both database and possible case-based support. By incorporating investigations of accidents in a SERA database, comparisons could be made between the current accident being investigated and past accidents. A different approach to such comparisons could make use of case-based systems that use and explicit methodology to examine prior cases for similarities and use those results to facilitate

decisions in the current investigation. Some interesting questions arise in the context of case-based reasoning such as when and how to intervene in an on-going investigation if the system determines that similarities to prior cases exist.

For either the database or case-based approach, the system would function as a repository of cases analysed. Given SERA's ability to link conclusions of investigations to HFACS categories at each stage in the investigation, all cases in the data/case-based system could serve as the objects of inference, relative to the current case.

Case-based reasoning would be one way of extending the intelligent aiding of SERA. The problem of deciding when and how to intervene to inform the user about possibly relevant cases to the current investigation could make use of the infrastructure already implemented in SERA that monitors user interface actions and infers current goals and plans of the user. Knowing "what" the user is doing at any given point during an investigation would go a long way to providing the needed information about when best to intervene.

This holds true for other possible intelligent aiding capabilities, e.g., helping out when the user is having problems making a decision, providing supplemental data and information when a conclusion reached using SERA is not consistent with the user's understanding of the situation and assisting in clarification when a user is unable to provide a clear answer to a question.

Agent technology, using large scale data stored on CD-ROMs or DVDs, or located on the Internet or Intranets could provide both general and specific information relevant to aspects of the accident under investigation. Information retrieval, filtering and presentation agents could be helpful in processing and using that information.

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Annexes

1. Annotated List of SERA Source Code Files

Annex 1

Annotated List of SERA Source Code Files

SERA Source Code Files (Windows and Macintosh Versions)

Collage.jpg

- This image file contains the collage that is displayed on the splash screen.

Dialogs.java

- This file contains the Java code for the dialogue boxes, including the HFACS window, the help prompt, the pop-up help windows and the "save changes" prompt.

Flowchart.java

- This file contains the Java code necessary for the SERA Flowchart window.

Main.java

- This file contains the Java code that serves as the main entry point when the application is launched.

MainWindow.java

- This file contains the Java code necessary for the main SERA window.

SERA.mcp

- This is the Metrowerks CodeWarrior project file.

Tab.jpg

- This image file contains the graphic of the tab used for the numbered unsafe acts in the flowchart window.

TabSel.jpg

- This image file contains the graphic of the tab used for the currently selected unsafe act in the flowchart window.

Title.jpg

- This image file contains the graphic of the SERA title that is displayed above the collage on the splash screen and at the top of all subsequent screens.

Tree.txt

- This file contains the text of questions, conclusions and pre-conditions, as well as information on the relationships among the nodes in the SERA decision tree.

SERA Source Code Files (Pocket PC Version)

Credits.jpg

- This image file contains the graphic of the developer credits screen.

Dialogs.java

- This file contains the Java code for the dialogue boxes, including the HFACS window, the help prompt, the pop-up help windows and the "save changes" prompt.

Flowchart.java

- This file contains the Java code necessary for the SERA Flowchart window.

Main.java

- This file contains the Java code that serves as the main entry point when the application is launched.

MainWindow.java

- This file contains the Java code necessary for the main SERA window.

SERA.bat

- This is an MS-DOS batch file which compiles the Java code and builds the application.

Splash.jpg

- This image file contains the graphic of the splash screen.

Tab.jpg

- This image file contains the graphic of the tab used for the numbered unsafe acts in the flowchart window.

TabSel.jpg

- This image file contains the graphic of the tab used for the currently selected unsafe act in the flowchart window.

Tree.txt

- This file contains the text of questions, conclusions and pre-conditions, as well as information on the relationships among the nodes in the SERA decision tree.

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14. ABSTRACT

Extensions are described for the Systematic Error and Risk Analysis (SERA) tool. SERA presents an investigator with a series of theoretically based questions and analyses the respondent's answers in terms of the source of failure and pre-conditions that led to that failure. Individual investigations using SERA may be saved and returned to at a later time and reports are available for export as text files, which then can be imported into a word processor for formatting. Extensions to SERA included accommodation for the investigation of multiple unsafe acts and porting of the software to a Personal Digital Assistant (PDA) for effective use in field settings. SERA provides a clear and intuitive interface, context-sensitive help and a foundation for intelligent aiding through an ability to track and represent user actions at the interface. Among the recommendations for future work were reliability and usability testing, designing and implementing an interface to accommodate voice input, where text would otherwise have to be keyed in by hand, and suggestions for intelligent aiding including the possible use of case-based reasoning.

RÉSUMÉ

On décrit ici un certain nombre d'extensions de l'outil ASER (analyse systématique des erreurs et du risque). Cet outil présente à l'enquêteur une série de questions théoriques et analyse ses réponses en termes de la cause de la défaillance et des conditions préalables qui l'ont provoquée. Les résultats d'enquêtes individuelles effectuées au moyen de l'outil ASER peuvent être sauvegardés et consultés ultérieurement, et les rapports peuvent être exportés sous la forme de fichiers texte; ces derniers peuvent ensuite être importés dans un traitement de texte pour être mis en page. Les extensions de l'outil ASER comportent la prise en compte dans l'enquête d'actes dangereux multiples, ainsi que le portage du logiciel sur un PDA (pour Personal Digital Assistant ou assistant numérique personnel) en vue d'une utilisation efficace sur le terrain. L'outil ASER comporte une interface claire et intuitive, une aide contextuelle, et les bases nécessaires pour une assistance intelligente, grâce à sa capacité de suivre et de représenter les actions entreprises par l'utilisateur au niveau de l'interface. Parmi les recommandations présentées en vue de travaux ultérieurs, citons des tests de fiabilité et d'utilisabilité, la conception et la mise en œuvre d'une interface vocale, permettant d'éviter la saisie du texte au clavier, et des suggestions pour une aide intelligente, notamment l'utilisation potentielle de raisonnements basés sur des cas.

15. KEYWORDS, DESCRIPTORS OR IDENTIFIERS

(U) HUMAN ENGINEERING TOOLS; HUMAN FACTORS ENGINEERING; SYSTEMATIC ERROR AND RISK ANALYSIS; SERA; ACCIDENT INVESTIGATION; HUMAN FACTORS ACCIDENT CLASSIFICATION SYSTEM; HFACS; AGA 135; MULTIPLE UNSAFE ACTS;; PERCEPTUAL CONTROL THEORY; IP/PCT; INTELLIGENT AIDING; TRACKING INTERFACE ACTIONS; AGENTS; AGENT TECHNOLOGY.